MGM DECONVOLUTION OF REFLECTANCE SPECTRUM OF THE Y981031 LUNAR METEORITE.

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Introduction: We report Modified gaussian model (MGM) deconvolution analyses [2] of reflectance spectrum of the Yamato (Y) 981031. Petrological characteristics of Y981031 had already reported [1]. Absorption features derived from the MGM deconvolution are compared with the petrological characteristics of Y981031, and implication of the absorption features are discussed. Finally, we propose source region of the meteorite using remote sensing data by future lunar exploration.

Method: One polished thin section (PTS) Y981031, 53-6 and one fragment of Y981031, 68 (0.13g) was supplied from National Institute of Polar Research (NIPR). The fragement of Y981031, 68 was crushed in an agate mortar, and then sieve out and collected particles of less than 75 µm for reflectance spectrum measurements. Reflectance spectrum of the powdered sample was measured by a JASCO UV-VIS-NIR reflectance spectrometer at National Space Development Agency of Japan (400-2600 nm in wavelength). Incidence and emission angles are 30^o and 0^o, respectively using Spectralon as reflectance standard. We also repeatedly measured reflectance spectrum of lunar soil 62231 since 62231 reflectance, which was measured at RELAB, was used as reflectance standard soil of Clementine data [3]. Using our 62231 measurements, we derived a correction factor (correction factor = reflectance by RELAB / reflectance our laboratory). The reflectance measurements of Y981031 are corrected using this correction factor to eliminate any differences between two laboratories.

Summary of petrology: Y981031 is a polymict regolith breccia, and contains a number of lithic clasts and mineral fragments in a dark comminuted matrix. The mineral fragments are 100 to 500 µm in size, and are composed of major pyroxene, plagioclase and olivine including minor iron oxide and Ca-phosphates [1]. The lithic clasts are mainly composed of mafic mare clasts, and some minor highland-origin lithic clasts are observed. The clasts of highland-origin include granulitic, poikilitic and glassy-matrix breccias. These mineralogical evidences suggest that Y981031 was derived from extensive mixing area of mafic mare and highland components. Fusion crust glasses are observed on one side of the thinsection. Since chemical compositions of the fusion glass resemble bulk rock compositions of Y981031 [4], the glass chemical compositions represent well-mixed bulk rock compositons [1]. The chemical compostions of Y981031 range TiO_2=0.50-0.77 wt.%, Al_2O_3=14.7-18.3 wt.%, and FeO=11.7-15.4 wt.%, suggesting mixing of mafic VLT affinity and feldspathic highland materials. Petrographical observations were also reported by Arai et al. [5] and Sugihara et al. [6].

Reflectance spectrum and MGM deconvolution: Natural log reflectance of Y981031, continuum and deconvolved absorption bands are shown in Fig. 1. Absorption bands are observed at 0.78, 0.90, 1.01, 1.22, 1.92, and 2.24 µm in wavelength. 1µm absorption bands due to Fe^{2+} absorption in mafic silicates would correspond to 0.90 and 1.01µm bands, and 2µm absorption bands correspond to 1.92 and 2.24µm. In Fig. 2, pyroxene chemical sompositions of the mineral fragments in Y981031 are shown with approximate contours of 1 and 2µm absorption bands wavelength in pyroxene quadrilateral [7]. Two absorption bands of 1µm (0.9 and 1.01µm) show existence of Mg-rich low-Ca pyroxene and augitic to ferroaugitic high-Ca pyroxene, and tendencies of 1µm bands consistent with those of two 2µm absorption bands (1.92 and 2.24µm).

Discussion: Such Mg-rich low-Ca pyroxene and augitic to ferroaugitic high-Ca payroxene are observed in Y981031 (Fig. 2). Although slight disagreements are observed, 0.90 and 1.92µm bands are of pigeonitic low-Ca pyroxene (up to Wo10En63Fs27). 1.01 and 2.24µm absorption bands are of the augitic to ferroaugitic high-Ca pyroxene mineral fragments. High-Ca pyroxene in Y981031 show a compositional trend (Wo43En40Fs17 to Wo29En23Fs48). This compositional trend is near parallel to the absorption contours around this region in pyroxene quadrilateral. Therefore, 1.01 and 2.24µm bands would be of the compositional trend of high-Ca pyroxene rather than one pyroxene composition. These observations indicate that Y981031 has predominantly high-Ca pyroxene and Mg-rich low-Ca pyroxene. We can also find 1.21µm absorption band. This absorption band can be attributed to plagioclase and/or olivine [8][9].

Chemical compositions of pyroxene in mafic mare clasts are included in the high-Ca pyroxene compositional trend in Fig. 2, and this result consistents with a result of Arai et al. [5]. Therefore, 1.01 and 2.24µm bands show characteristics of the VLT affinity as mafic components in Y981031. Relatively wide exsolution lamellae is observed in Mg-rich low-Ca pyroxene fragments under the microscope, and Ti# (Ti/(Ti+Cr), atomic ratio)-Mg# (Mg/(Mg+Fe), atomic ratio) relation of the low-Ca pyroxene fragments resemble those of highland pyroxene shown by Arai et al. [10]. Therefore, Mg-rich low-Ca pyroxene would be derived from highland materials.

We can observe absorption features derived from mafic VLT and mixed highland materials in Y981031 by the MGM analyses. TiO_2 and FeO concentrations of the fusion glass and bulk rock [4] resemble those of Mare Frigoris and adjacent maria that were derived from Clementine images using Lucey et al. algorithms [11]. Therefore, Y981031 may be launched from a region in these maria. If we observe these maria by ground-based telescopic or future hyperspectral remote sensing observations, we can identify source region of the meteorite having same absorption characteristics.

Conclusion: In comparison between petrological and reflectance spectroscopic observations, we successfully identified reflectance spectroscopic characteristics of two endmembers in Y981031 that is mixtures of mafic VLT components and feldspathic highland components. This result suggest that we can separately identify some mixing endmembers even if in mare-highland mixing area such as mare-highland contact using hyperspectral remote sensing data and the MGM analyses. Therefore, if we carry out petrological observations in detail and measure reflectance spectrum of a lunar meteorite, we can not only understand source region of the meteorite from remote sensing data but also use the meteorite as ground truth of the remote sensing data around the source region.

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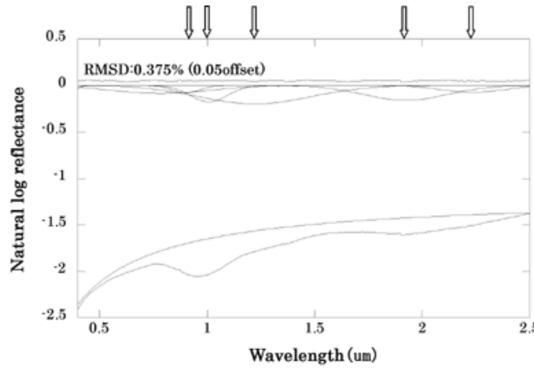

Fig. 1. Bi-directional reflectance spectrum and deconvolved results of Y981031. RMS error is presented in upper most of the diagram with 0.05 offset. Arrows above graph indicate positions of absorption bands (0.90, 1.01, 1.22, 1.92, 2.24 μm in wavelength).

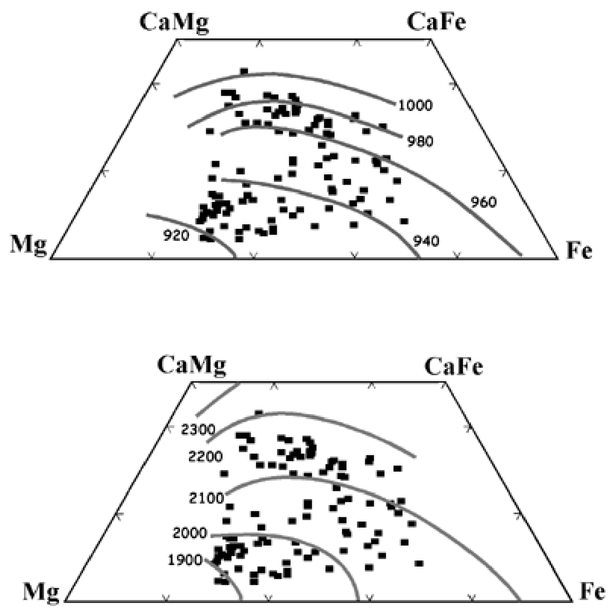

Fig. 2. Pyroxene chemical compositions and approximate contours of 1 and 2 μm absorption bands of pyroxene. in pyroxene quadrilateral The contours are from Cloutis and Gaffey [6].